Formulating 50 VOC Gloss Floor Paints

by Greg Monaghan
Yoplait and Usao Company*

South Coast Air Quality Management District (SCAQMD) requirements that gloss floor paints contain no more than 50 g/l volatile organic compounds (VOC) means that solvent-based urethane alkyds and 200 VOC latex gloss floor paints will need to be reformulated for sale in the Los Angeles area. Although there are now many binders offered for 50 VOC gloss trim paints, gloss floor paints require a different balance of properties. Of particular importance is that the paint should coalesce at lowcoulomb levels but still be hard enough that it does not pick up dirt or scuff easily under foot traffic. A novel accelerated wear testing machine was used to screen binder chemistries for gloss floor paints. A 50 VOC paint based on a combination of a water-based ambient temperature crosslinking polymer with a water-dispersible oil-modified urethane has been found to give performance equal to commercial solvent-based urethane alkyd and commercial 200 VOC water-based gloss floor paints.

INTRODUCTION

Floor paints are used in basement areas, on patios, porches, and exterior stairs. Floor and patio paints are often used to brighten the living space and give it a more distinctive, finished look. In addition to the aesthetic appeal of the painted floor, the coating also is functional. The paint helps reduce dust from the concrete floor and the painted surface is easy to clean if there are spills of household chemicals. Since they are exposed to foot traffic or to scraping or marring from moving furniture, these floor paints also need good hardness and scuff resistance. Good exterior durability is desirable, although most floor paints are not designed to be used on exposed wood decks.

Most paint companies offer a water-based satin or flat floor finish and a solvent-based gloss finish, usually a urethane alkyd blend. VOC regulations of 50 g/l in California’s South Coast Air Quality Management District (SCAQMD) are driving the reformulation of oil-based gloss floor paints to water-based paints. Several water-based gloss floor paints are on the market, however, these are close to 200 g/l VOC.

Floor and patio paints are usually not recommended for garages. Let’s use thermoplastic crosslinking paints are needed for garages where hot tire pick-up is a problem. Water and heat from the tires can soften the film, thus the pressure and plasticizers in the tire can bond the tire to the paint. In addition, tires often leave unsightly black marks on the surface of paint.

Low-VOC gloss binders based on one-part ambient temperature thermosetting crosslinking acrylic technology were investigated for possible use in both floor paints and garage floor paints. On full cure, these paints might be expected to be less thermoplastic than conventional acrylics; however, these binders can take several weeks to reach full cure. To speed the cure, blends with water-reducible oil-modified urethanes or dispersions of epoxy esters might be used. The oxidative cure of the dicyclohexyl urethane of the epoxy ester, and the oil-modified urethane forms carbon-carbon, ether, or peroxide bonds. Further decomposition of the peroxides can give carbonyl functional groups, which can in turn react with the ambient temperature crosslinking acrylic, giving a higher crosslink density. This reaction is much more rapid than the crosslinking of the acrylic, and reaches completion in days instead of weeks, giving significant improvement in hardness.

The water-reducible epoxy esters and oil-modified urethanes have some other benefits in floor paints. The epoxy ester and oil-modified urethanes can improve the adhesion of the paints to concrete and give the film better chemical resistance. They can also act as coalescents and can provide low-VOC paints with better early hardening than plastified formulations based on conventional binders.

Several authors have investigated the use of crosslinking acrylics with either polyurethane dispersions or oil-modified urethanes.1 The goal has been to provide a film with the characteristic acrylic properties of excellent weather resistance, water and chemical resistance, and improve the film resistance to low temperature and impact resistance with urethane modification. This combination of properties is desirable in gloss floor paints but has not been demonstrated in low-VOC gloss floor paint formulations before.

MATERIALS

An ambient temperature crosslinking acrylic binder (referred to in this article as XL Acrylic) was formulated into a gloss floor paint either as the sole vehicle or in 80/20 blends with water-reducible oil-modified urethane (Uronol® F-97 MPW-33 from Reichhold). (Appendix 1) or epoxy ester emulsion (Epoxid® 36-694 from Reichhold). These paints were compared to several commercial gloss floor paints. Two of the commercial gloss floor paints were solvent-based urethane alkyds with VOC greater than 500 g/l and two were water-based gloss floor paints at 187 and 229 VOC, respectively. The experimental formulation was a 50 VOC, 19% PVC, 34% volume solids gloss paint with 0.05% thickener. Coalescent levels were adjusted to give good low temperature coalescence at 40°F and then VOC was adjusted to 50 g/l using propylene glycol. Floor paints were formulated at 50% KI and 1.3% paints which contained drying oil functional groups were formulated with a tung oil dispersions (Manganese Hydroxide III from OMG Co.) designed for use in water-based paints.

A second set of paints selected from this bench marking study was compared to a commercial water-based two-part epoxy garage floor paint for hot tire pick-up resistance and black tire marking.

TEST METHODS AND RESULTS

Coalescent Demand

Low temperature coalescence tests were run at 40° F.

A 6 mil drawdown was made on a weighed and unsealed Lexan® 18 drawdown card, dried at 60°F and 50% relative humidity for 7 days, then rated for cracking. The XL Acrylic paint needed just 30% Texanol to pass (no cracks on either sealed or unsealed) chart area. The crosslinking acrylic paints modified with either the epoxy ester or the oil-modified urethane did not need coalescent to pass this test. One of the commercial latexes failed the low temperature test.

Gloss

The range of 60° glosses of the commercial control floor paints was quite large, with values from 50 to 72. The 60° gloss of the XL Acrylic paint was in the middle of the range of the commercial paints (at 56). Modifying the XL Acrylic paint with either the epoxy ester or the oil-modified urethane (OMU) gave lower glosses (78 for the OMU XL Acrylic paint); however, the gloss of the OMU modified paint was still close to the gloss of two of the commercial controls.

Early Black Resistance

To evaluate hardness, face to face blocking tests were run after an overnight dry either at high temperature.
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South Coast Air Quality Management District (SCAQMD) requirements that gloss floor paints contain no more than 50 g/l volatile organic compounds (VOC) means that solvent-based urethane alkyds and 200 VOC latex gloss floor paints will need to be reformulated for sale in the Los Angeles area. Although there are now many binders offered for 50 VOC gloss trim paints, gloss floor paints require a different balance of properties. Of particular importance is that the paint should coalesce at low coater speeds but still be hard enough that it does not pick up dirt or scuff easily under foot traffic. A novel accelerated-roll coating machine was used to screen binder chemistries for gloss floor paints. A 50 VOC paint based on a combination of a water-based ambient temperature crosslinking polymer with a water-dispersible oil-modified urethane has been found to give performance equal to commercial solvent-based urethane alkyds and commercial 200 VOC water-based gloss floor paints.

INTRODUCTION

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Most paint companies offer a water-based satin or flat floor finish and a solvent-based gloss finish, usually a urethane alkyd blend. VOC regulations of 90 g/l, in California's South Coast Air Quality Management District (SCAQMD) are driving the reformulation of oil-based gloss floor paints to water-based paint. Several water-based gloss floor paints are on the market; however, these are close to 200 g/l VOC.

Floor and patio paints are usually not recommended for garages. Let's thermoplastic crosslinking paints are needed for garages where hot tire pick-up is a problem. Water and dirt from the tires can soften the film, thus the pressure and plasticizers in the tires can bond the tire to the paint. In addition, tires often leave unsightly black marks on the surface of paint.

Low-VOC gloss binders based on one-part ambient temperature curative crosslinking acrylic technology were investigated for possible use in both floor paints and garage floor paints. On full cure, these paints might be expected to be less thermoplastic than conventional acrylics; however, these binders can take several weeks to reach full cure. To speed the cure, blends with water-reducible oil-modified urethanes or dispersions of epoxy esters might be used. The oxidative cure of the diallylic unsaturation of the epoxy ester, and the oil-modified urethane forms carbon-carbon, ether, or peroxide bonds. Further decomposition of the peroxides may give carboxyl functional groups, which can in turn react with the ambient temperature crosslinking acrylic, giving a higher crosslink density. This reaction is much more rapid than the crosslinking of the acrylic, and reaches completion in days instead of weeks, giving significant improvement in early hardness. The water-reducible epoxy ester and oil-modified urethanes have some other benefit in floor paints. The epoxy ester and oil-modified urethanes can improve the adhesion of the paints to concrete and give the film better chemical resistance. They can also act as coalescents and can provide low-VOC paints with better early hardness than plastified formulations based on conventional binders.

Several authors have investigated the use of crosslinking acrylics with either polyurethane dispersions or oil-modified urethanes. The goal has been to provide a film with the characteristic acrylic properties of excellent weather resistance, water and chemical resistance, and improve the coater resistance and low-temperature weathering resistance with urethane modification. This combination of properties is desirable in gloss floor paints but has not been demonstrated in low-VOC gloss floor paint formulations before.

MATERIALS

An ambient temperature crosslinking acrylic binder (referred to in this article as XL Acrylic*) was formulated into a gloss floor paint either as the sole vehicle or in 80/20 blends with water-reducible oil-modified urethane (Utron*) 597 MPW-33 from Reichhold (Appendix 1) or epoxy ester emulsion (Epolit® 36-694 from Reichhold). These paints were compared to several commercial gloss floor paints. Two of the commercial gloss floor paints were solvent-based urethane alkyds with VOC greater than 500 g/l and two were water-based gloss floor paints at 187 and 229 VOC, respectively. The experimental formulation was a 50 VOC, 19% PVC, 34% volume solids gloss paint with TEOL thickener. Coalescent levels were adjusted to give good low temperature coalescence at 30°C and then VOC was adjusted to 50 g/l using propylene glycol. Floor paints were formulated at 50% and 1.3 pH paints which contained drying oil functional groups were formulated with a manganous dicyandihydrosuccinate (Manganese Hydroxide III from OMG Coatings) designed for use in water-based paints.

A second set of paints selected from this benchmarking study was compared to a commercial water-based two-part epoxy garage floor paint for hot tire pick-up resistance and black tire marking.

TEST METHODS AND RESULTS

Coalescent Demand

Low temperature coalescence tests were run at 40°F.
A 6 mm drawdown was made on a sealed and unsealed Leotex* 18 drawdown card, dried at 23°C for 24 hours, then rated for cracking. The XL Acrylic paint needed just 3% Texanol to pass (no cracks on either sealed or unsealed chart cards). The crosslinking acrylic paints modified with either the epoxy ester or the oil-modified urethane did not need coalescent to pass this test. One of the commercial latex paints failed the low-temperature test.

Gloss

The range of 60° glosses of the commercial control floor paints was quite large, with values from 90 to 72. The 60° gloss of the XL Acrylic paint was in the middle of the range of the commercial paints (at 96). Modifying the XL Acrylic paint with either the epoxy ester or the oil-modified urethane (OMU) gave lower glosses (76 for the OMU XL Acrylic paint); however, the gloss of the OMU modified paint was still close to the gloss of two of the commercial controls.

Early Block Resistance

To evaluate hardness, face to face blocking tests were run after an overnight dry either at high temperatures.
the paint was then rinsed off of the paint with water and light wiping with a piece of wet cheesecloth. The panels were cleaned until no more iron oxide slurry was being picked up by the cheesecloth, then the color difference (Delta E) was read between the area coated with the iron oxide slurry and a control area with no iron oxide slurry. In this test, larger Delta E numbers indicate that more iron oxide pigment is left on the surface of the paint and may be an indication of the film hardness since the more pigment may become imbedded into a sofer paint film. In this laboratory dirt pick-up resistance test, the XL Acrylic was good but the OMIU-modified XL Acrylic paint was rated as very good. The XL Acrylic with OMIU was better than all but one of the commercial control paints. The crosslinking acrylic modified with epoxy ester had slightly worse performance than the crosslinking acrylic alone.

Oil Softening Resistance

The paints were also tested for oil softening resistance using hand cream and a slurry of iron oxide pigment (Figure 1). The hand cream was applied to the panels and then wiped off the panels 16 hr later. The iron oxide slurry was then applied to the panel, allowed to dry, and rinsed off. The panels were then rated for color changes. The hand cream softening test is quite severe, and most paints soften significantly, giving a very dark color where the hand cream and iron oxide slurry is applied. In this test, the XL Acrylic paints were equal to the solvent-based commercial controls and were much better than the two aqueous floor paint commercial controls.

Abrasive Scrub Resistance

Abrasve scrub tests were also run on a Gardner Abrasion Tester using the Leneta Abrasive Scrub Media SC-2. Side by side drawdowns (3 wet mils) were made against the control paint with the XL Acrylic as the sole binder. Shims were used under the paints and the number of cycles to cut through across the shim was recorded. In this scrub testing, the control XL Acrylic paint was equal to one of the commercial latex gloss floor paints (Aqueous Floor Paint #2 at 187 VOC). Modifying the XL Acrylic paint with the OMIU improved the scrub resistance by 30%. Although the XL Acrylic paint with the OMIU was better than one of the commercial controls, it was still lower than the other three commercial controls for scrub resistance.

Household Cleaner Resistance

Resistance to household cleaners was tested at one-week cure (Table 1). In this test, loss of gloss and film degradation were evaluated after 200 cycles on the Gardner Abrasion Tester using a 1 lb boat resting on cheesecloth saturated with Fantastik®. In the household cleaner resistance test, all of the XL Acrylic paints and the oil-based controls had excellent resistance to Fantastik. Both of the ~200 VOC commercial water-based gloss floor paint controls had poor household cleaner resistance and lost a significant amount of gloss.

Adhesion to Gloss Alkyd

Since some floors were previously painted with glossy alkyd paint, the new adhesion to gloss alkyd was also measured. Paints were brushed onto a gloss alkyd panel which had been cured for six weeks. After the experimental paints had dried for one week, the panels were placed into a streaming fog box for five hours. The test paints were then tested for adhesion using a knife peel test (rated 1=10; 10=best) and a cross hatch tape pull test. All the paints except for one of the water-based commercial controls (Commercial Latex Paint #2) had very good adhesion to gloss alkyd substrate after one week dry.

Table 1—Resistance Properties of Gloss Floor Paint

<table>
<thead>
<tr>
<th>Test</th>
<th>X1 Acrylic</th>
<th>X1 Acrylic OMIU</th>
<th>Solvent Brown Floor Pt #1</th>
<th>Solvent Brown Floor Pt #2</th>
<th>Aqueous Floor Pt #1</th>
<th>Aqueous Floor Pt #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOC (g/L)</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>350</td>
<td>100</td>
</tr>
<tr>
<td>% Tensile % Elongation</td>
<td>3%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>40 % FTE, 0.01 DD</td>
<td>Pass</td>
<td>Pass</td>
<td>Pass</td>
<td>Not</td>
<td>Run</td>
<td>Run</td>
</tr>
<tr>
<td>20°/60° glass</td>
<td>57.82</td>
<td>48.73</td>
<td>46.76</td>
<td>78.90</td>
<td>35.72</td>
<td>48.17</td>
</tr>
<tr>
<td>Block one day dry @KT</td>
<td>6.5</td>
<td>6.5</td>
<td>6</td>
<td>6.5</td>
<td>6</td>
<td>6.5</td>
</tr>
<tr>
<td>Print one week dry</td>
<td>5</td>
<td>6</td>
<td>6.5</td>
<td>6.5</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Lab SRU Delta E</td>
<td>1.7</td>
<td>1.5</td>
<td>3.8</td>
<td>11.4</td>
<td>5.5</td>
<td>10.1</td>
</tr>
<tr>
<td>Scrub % of control</td>
<td>Control</td>
<td>96</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Fastness resistance</td>
<td>60° gloss test</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Note: Results were color coded compared to the control 100% X1 Acrylic paint. Properties shaded in blue were worse than the control; those shaded in green were better. Modifying the XL Acrylic paint with OMIU gave improved block, print, dirt pick-up resistance, and scrub resistance.

March 2009

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the paint was then rinsed off of the paint with water and light wiping with a piece of wet cheesecloth. The panels were cleaned until no more iron oxide was being picked up by the cheesecloth, then the color difference (Delta E) was read between the area coated with the iron oxide slurry and a control area with no iron oxide slurry. In this test, larger Delta E numbers indicate that more iron oxide pigment is left on the surface of the paint and may be an indication of the film hardness since the more pigment may become imbedded into a softer paint film. In this laboratory dirt pick-up resistance test, the XL Acrylic was good but the OMUI-modified XL Acrylic paint was rated as very good. The XL Acrylic with OMUI was better than all but one of the commercial control paints. The crosslinking acrylic modified with epoxy ester had slightly worse performance than the crosslinking acrylic alone.

Oil Softening Resistance

The paints were also tested for oil softening resistance using hand cream and a slurry of iron oxide pigment (Figure 1). The hand cream was applied to the panels and then wiped off the panels 16 hr later. The iron oxide slurry was then applied to the panel, allowed to dry, and rinsed off. The panels were then rated for color changes. The hand cream softening test is quite severe, and most paints soften significantly, giving a very dark color where the hand cream and iron oxide slurry is applied. In this test, the XL Acrylic paints were equal to the solvent-based commercial controls and were much better than the two aqueous floor paint commercial controls.

Abrasive Scrub Resistance

Abrasive scrub tests were also run on a Gardner Abrasion Tester using the Lenota Abrasive scrub Media SC-2. Side by side drawdowns (3 wet mils) were made against the control paint with the XL Acrylic as the sole binder. Shims were used under the paints and the number of cycles to cut through across the shim was recorded. In this scrub testing, the control XL Acrylic paint was equal to one of the commercial latex gloss floor paints (Aqueous Floor Paint #2 at 187 VOC). Modifying the XL Acrylic paint with the OMUI improved the scrub resistance by 30%. Although the XL Acrylic paint with the OMUI was better than one of the commercial controls, it was still lower than the other three commercial controls for scrub resistance.

Household Cleaner Resistance

Resistance to household cleaners was tested at one-week cure (Table 1). In this test, loss of gloss and film degradation were evaluated after 200 cycles on the Gardner Abrasion Tester using a 1 lb boat resting on cheesecloth saturated with Fantastik®. In the household cleaner resistance test, all of the XL Acrylic paints and the oil-based controls had excellent resistance to Fantastik. Both of the ~200 VOC commercial water-based gloss floor paint controls had poor household cleaner resistance and lost a significant amount of gloss.

Adhesion to Gloss Alkyd

Since some floors were previously painted with glossy alkyd paint, the wet adhesion to gloss alkyd was also measured. Paints were brushed onto a gloss alkyd panel which had been cured for six weeks. After the experimental paints had dried for one week, the panels were placed into a streaming fog box for five hours. The test paints were then tested for adhesion using a knife peel test (rated 1–10; 10 = best) and a cross hatch tape pull test. All the paints except for one of the water-based commercial controls (Commercial Latex Paint #2) had good very good adhesion to gloss alkyd substrate after one week dry.
Figure 3—Taber abrasion resistance of porch and floor paints. The Taber abrasion resistance of the paints with the XL Acrylic/OMU was better (less weight loss at 600 cycles) than the commercial control porch and floor paints.

Stained area compared to an unstained area of the drawdown. All the floor paints except one of the water-based commercial paints (Aqueous Floor Paint #1) were very good for stain removal with 1% Tide.

Chemical Resistance
To check resistance to household chemicals (Formula 409, isopropanol, bleach, 90 proof alcohol, ammonia, and 1% Tide*), spot tests were run and rated after 30 min exposure. The chemical spots were rated for blistering, change in color, loss of gloss, softness, and recovery after an overnight dry. Most of the paints were very good for all the tested chemicals, but the two water-based commercial gloss floor paints were slightly worse than the crosslinking acrylic in spot tests for household cleaners and alcohol.

Abrasion Resistance
Abrasion resistance was tested on a Taber Abraser using CS-17 wheels and 500 g weight per wheel. The weight loss of the coating at 600 cycles was measured. In this test, lower numbers are better (less paint loss by abrasion). The Taber abrasion resistance (Figure 3, Table 2) of the crosslinking acrylic and the oil-modified urethane with crosslinking acrylic were good, and equal to the water-based commercial controls. Interestingly, the solvent-based floor paints had worse Taber abrasion resistance than the paint with XL Acrylic as the sole binder.

Accelerated Wear Testing
Abrasion resistance, gloss retention, and dirt pick-up resistance was also tested using an Accelerated Wear Tester* patented by Rohm and Haas (Figure 4). In this test, the paints were drawn down on vinyl floor tiles, then placed on a moving belt which subjected the tiles to dirt, pressure to grind the dirt into the panel, dry abrasion under a leather pad (to simulate foot traffic), rinsing with plain water and a cleaning pad, and then drying. After each cycle, the 60° gloss was recorded on each panel. Dirt pick-up resistance is rated visually at the end of 25 cycles. In tests with floor polishes, this machine gives results in one day which correlate well with three month tests on actual floors; however, it is best used as a relative test to a control of known performance. In addition to accelerating the wear of the paints, the wear tester also gives much better control of test conditions than the actual floor applications, and helps ensure that all paints are subjected to the same wear.

In the accelerated wear test (Figures 5 and 6; Table 3), the crosslinking acrylic was slightly low for gloss retention but was equal to one of the commercial controls for gloss retention after 25 cycles. Using the combination of the crosslinking acrylic with the oil-modified urethane improved the gloss retention significantly. The dirt pick-up resistance was also improved with the oil-modified urethane. In rating the dirt pick-up resistance, a visual ranking was used, and dirt streaks were evaluated.

Table 3—Accelerated Wear Test Results

<table>
<thead>
<tr>
<th>VOC (g/L)</th>
<th>50</th>
<th>50</th>
<th>50</th>
<th>300</th>
<th>400</th>
<th>229</th>
<th>187</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stain removal Delta E after cleaning (200 cycles) with 1% Tide vs unstained</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coffee</td>
<td>3</td>
<td>2.2</td>
<td>2.8</td>
<td>2.3</td>
<td>2.2</td>
<td>2.2</td>
<td>1.1</td>
</tr>
<tr>
<td>Tea</td>
<td>2.6</td>
<td>1.9</td>
<td>1.7</td>
<td>1.6</td>
<td>1.1</td>
<td>1</td>
<td>1.3</td>
</tr>
<tr>
<td>Grape juice</td>
<td>0.1</td>
<td>0.1</td>
<td>0.2</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Leneta stain</td>
<td>1.7</td>
<td>0.7</td>
<td>0.6</td>
<td>0.1</td>
<td>0.1</td>
<td>1.1</td>
<td>2.2</td>
</tr>
</tbody>
</table>

Note: One of the commercial controls was poor for stain removal. In the chemical spot test, the two aqueous commercial gloss floor paint controls were poor for household cleaner resistance and alcohol resistance. The two commercial solvent-based controls were slightly worse than the other paints for Taber abrasion resistance.

Table 2—Stain, Chemical, and Abrasion Resistance of Gloss Floor Paints

<table>
<thead>
<tr>
<th>Experimental Gloss Porch and Floor Paint: 19.3 PVC, 34.1% vs 50 VOC Thickened with RM-2020MR and BR-6W</th>
<th>100% XL Acrylic</th>
<th>80% XL Acrylic/ 20% Epoxy Ester</th>
<th>60% XL Acrylic/ 40% OMU</th>
<th>Cone 63, Pt. #1</th>
<th>Cone 63, Pt. #2</th>
<th>Cone 63, Latex Pt. #1</th>
<th>Cone 63, Latex Pt. #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOC (g/L)</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>300</td>
<td>400</td>
<td>229</td>
<td>187</td>
</tr>
<tr>
<td>Stain removal Delta E after cleaning (200 cycles) with 1% Tide vs unstained</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coffee</td>
<td>7</td>
<td>8</td>
<td>8</td>
<td>9</td>
<td>8</td>
<td>6</td>
<td>6</td>
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<tr>
<td>70% IPH</td>
<td>8</td>
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<td>9</td>
<td>7</td>
<td>8</td>
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<td>6</td>
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<td>30% Bleach</td>
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<td>10</td>
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<td>90 Proof alcohol</td>
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<td>8</td>
<td>9</td>
<td>7</td>
<td>7</td>
<td>6</td>
<td>6</td>
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<tr>
<td>Anisole</td>
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<td>10</td>
<td>10</td>
<td>10</td>
<td>9</td>
<td>9</td>
<td>10</td>
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<td>1% Tide</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Taber abrasion resistance: ES-17 wheels, 500 g</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Weight loss, 600 cycle</td>
<td>-0.0229</td>
<td>-0.0038</td>
<td>-0.0036</td>
<td>-0.0062</td>
<td>-0.0064</td>
<td>-0.04</td>
<td>-0.0269</td>
</tr>
</tbody>
</table>

Note: One of the commercial controls was poor for stain removal. In the chemical spot test, the two aqueous commercial gloss floor paint controls were poor for household cleaner resistance and alcohol resistance. The two commercial solvent-based controls were slightly worse than the other paints for Taber abrasion resistance.

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Figure 4—Rohm and Haas Accelerated Wear Tester. Paints were drawn down on floor tiles, then placed on a moving floor which passed beneath the stations in the wear tester. Light burnishing was used in the first station and the cleaning station used plain water. Panels were soiled with dry dirt which was ground into the paint by the roller. In the scuffing station, the rollers wore (normally used to simulate black heel marks) were replaced with a flat leather pad to simulate wear under foot traffic.

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Figure 3—Taber abrasion resistance of porch and floor paints. The Taber abrasion resistance of the paints with the XL Acrylic/OMU was better (less weight loss at 600 cycles) than the commercial control porch and floor paints.

Chemical Resistance
To check resistance to household chemicals (Formular 409, isopropanol, bleach, 90%proof alcohol, ammonia, and 1% TIE), spot tests were run and rated after 30 min exposure. The chemical spots were rated for blistering, change in color, loss of gloss, softness, and recovery after an overnight dry. Most of the paints were very good for all the tested chemicals, but the two water-based commercial gloss floor paints were slightly worse than the crosslinking acrylic in spot tests for household cleaners and alcohol.

Abrasion Resistance
Abrasion resistance was tested on a Taber Abrasort® using CS-17 wheels and 500 g weight per wheel. The weight loss of the coating at 600 cycles was measured. In this test, lower numbers are better (less paint loss by abrasion). The Taber abrasion resistance (Figure 3, Table 2) of the crosslinking acrylic and the oil-modified urethane with crosslinking acrylic were very good, and equal to the water-based commercial controls. Interestingly, the solvent-based floor paints had worse Taber abrasion resistance than the water-based paints. The XL Acrylic paint modified with the epoxy ether had worse Taber abrasion resistance than the paint with XL Acrylic as the sole binder.

Accelerated Wear Testing
Abrasion resistance, gloss retention, and dirt pick-up resistance was also tested using an Accelerated Wear Tester® patented by Rohm and Haas (Figure 4). In this test, the paints were drawn down on vinyl floor tiles, then placed on a moving belt which subjected the tiles to dirt, pressure to grind the dirt into the panel, dry abrasion under a leader pad (to simulate foot traffic), rinsing with plain water and a cleaning pad, and then drying. After each cycle, the 60° gloss was recorded on each panel. Dirt pick-up resistance is rated visually at the end of 25 cycles. In tests with floor polishes, this machine gives results in one day which correlate well with three month tests on actual floors; however, it is best used as a relative test to a control of known performance. In addition to accelerating the wear of the paints, the wear tester also gives much better control of test conditions than the actual floor applications, and helps ensure that all paints are subjected to the same wear.

In the accelerated wear test (Figures 5 and 6; Table 3), the crosslinking acrylic was slightly low for gloss retention but was equal to one of the commercial controls for gloss retention after 25 cycles. Using the combination of the crosslinking acrylic with the oil-modified urethane improved the gloss retention significantly. The dirt pick-up resistance was also improved with the oil-modified urethane. In rating the dirt pick-up resistance, a visual ranking was used, and dirt streaks were evaluated.
Figure 5—Dirt pick-up resistance. One-week dry, 25 cycles in accelerated wear test. Dirt streaking was rated visually on a 1-10 scale. The XL Acrylic was slightly better than one of the solvent-based gloss floor paints, while the XL Acrylic with oil-modified urethane was equal to the best of the commercial gloss floor paints (DU rating of 6). The slightly yellower color of the solvent-based controls and the OML-modified XL Acrylic was due to the yellowness of the paints, and was not caused by increased dirt pick-up.

Hot Tire Pick-Up and Black Tire Mark Tests

Hot tire pick-up testing was also run on a few of the paints (Figure 7). Concrete test panels were prepped by scrubbing with an acid wash, rinsing, and drying for 72 hr. The panels had the experimental paints drawn down (10 mils wet) side by side with a pass control (a commercial two-part water-based gloss epoxy garage floor paint) and were aged for one week before testing. In order to simulate a garage application, a car with warm tires (30 min summer highway driving) was rolled onto painted smooth concrete test panels (the panels were placed only under the front wheels so they would be subjected to roughly equal weight). After 16 hr of pressure, the panels were visually rated for paint removal and black tire marks.

In this dry hot tire test, there were very large differences in the degree of black tire marks. The paint with the XL Acrylic was worse than the commercial two-part epoxy control for black tire marks. The black tire mark resistance of the XL Acrylic was improved when it was used with the OML or with the epoxy ester; however, the performance was still not equal to the two-part epoxy garage floor paint. Some lifting of the paint from the concrete was noted in the XL Acrylic/OML blend and the XL Acrylic/epoxy ester blends.

DISCUSSION

The benefits of ambient temperature curing acrylic chemistry in the XL Acrylic binder can be seen in the performance in floor paints at 50 VOC. The 50 VOC XL Acrylic paints were similar in most properties to commercial 200 VOC gloss latex floor paints. This toughness is seen in the dirt pick-up resistance, the household cleaner resistance, and block resistance. The excellent adhesion of the XL Acrylic to the aged gloss alkyd is also a property of the crosslinking chemistry since aldehydes on the surface of the aged alkyd film can form bonds with the crosslinking acrylic.

Modifying the crosslinking acrylic with water-dispersible OML gave improved performance which is close to that of the solvent-based floor paints. The OML-modified crosslinking acrylic paint did not need coalescent and had excellent early hardness and print resistance. Accelerated wear testing showed that the OML-modified paint would be expected to have the durability on a floor that solvent-based floor paints have. The improved properties may be due in part to the mar resistance of the OML but also may be due in part to increased crosslink density of the OML-modified XL Acrylic. The OML-modified acrylics did have slightly more yellowness and also had lower 20° gloss than the unmodified crosslinking acrylic.

Modifying the crosslinking acrylic with an epoxy ester did not give the same improved performance as the OML modification. The epoxy ester-modified paint had worse dirt pick-up resistance and worse Faber abrasion resistance than the crosslinking acrylic alone. The expected epoxy ester modification benefits of improved chemical resistance and improved adhesion to concrete were also not found. The lack of improved properties may be due to binder incompatibility; however, more work is needed to confirm this.

The XL Acrylic is not suitable for garage floors when used as the sole binder because it was poor for black tire marks at one week dry. The performance was significantly improved when the XL Acrylic was used with 20% oil-modified urethane or epoxy ester. It is not clear from this study if the XL Acrylic/OML or XL Acrylic/epoxy ester paints had better black tire mark resistance because they were harder after one week cure, or if the Texanol in the 100% XL Acrylic control hurt the resistance to black tire marks. More work needs to be done to determine the effect of these variables and to see if even better performance can be obtained at higher levels of epoxy ester or oil-modified urethane. Although the XL Acrylic/OML paint had improved performance compared to the 100% XL Acrylic paint, it was not equal to the commercial two-part epoxy garage floor paint control and that experimental formulation would not be suitable for garage floor application.

CONCLUSION

A 50 VOC floor paint based on a one-part ambient temperature crosslinking acrylic had performance similar to two commercial latex gloss floor paints formulated at 170–225 VOC. Modifying the crosslinking acrylic paint with 20% of a water-dispersible OML gave improved performance nearly equal to the solvent-based gloss floor paints. The combination of water-dispersible OML and an ambient temperature crosslinking acrylic gives excellent performance in floor paints which meet the South Coast Air Quality Management District’s 50 g/L VOC limits.

References


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Technology Today

Figure 7—Hot tire pick-up test. Compared to a two-part commercial epoxy garage floor paint, the XL Acrylic was worse for black tire marks. Modifying the XL Acrylic with either OML or epoxy ester improved the black tire marks; however, the modified paints were not equal to the control two-part epoxy garage floor paint.

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Modifying the crosslinking acrylic with water-dispersible OUMI gave improved performance which is close to that of the solvent-based floor paints. The OUMI-modified crosslinking acrylic paint did not need coalescent and had excellent early hardness and print resistance. Accelerated wear testing showed that the OUMI-modified paint would be expected to have the durability on a floor that solvent-based floor paints have. The improved properties may be due in part to the resin resistance of the OUMI but also may be due in part to increased crosslink density of the OUMI-modified XL Acrylic. The OUMI-modified acrylics did have slightly more yellowness and also had lower 20° gloss than the unmodified crosslinking acrylic.

Modifying the crosslinking acrylic with an epoxy ester did not give the same improved performance as the OUMI modification. The epoxy ester-modified paint had worse dirt pick-up resistance and worse Taber abrasion resistance than the crosslinking acrylic alone. The expected epoxy ester modification benefits of improved chemical resistance and improved adhesion to concrete were also not found. The lack of improved properties may be due to binder incompatibility; however, more work is needed to confirm this.

The XL Acrylic is not suitable for garage floors when used as the sole binder because it was poor for black tire marks at one week dry. The performance was significantly improved when the XL Acrylic was used with 20% oil-modified urethane or epoxy ester. It is not clear from this study if the XL Acrylic/OUMI and XL Acrylic/epoxy ester paints had better black tire mark resistance because they were harder after one week cure, or if the Texanol in the 100% XL Acrylic could hurt the resistance to black tire marks. More work needs to be done to determine the effect of these variables and to see if even better performance can be obtained at higher levels of epoxy ester or oil-modified urethane. Although the XL Acrylic/OUMI paint had improved performance compared to the 100% XL Acrylic paint, it was not equal to the commercial two-part epoxy garage floor paint control and that experimental formulation would not be suitable for garage floor application.

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